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New generation of LSCF oxygen transport membranes

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Reduction of anthropogenic CO_2 emissions is one of the greatest current societal challenges. One technology to meet this challenge is capturing CO_2 in fossil fuelled power plants using the oxyfuel concept. Oxygen transport membranes (OTM) exhibit high potential to supply the pure oxygen required by this oxyfuel technology in large scale [1]. Due to the high demand on oxygen (134 kg/s for a large coal power plant with 1.5 GW thermal power) a lot of research is done to increase the permeation rates in order to limit the necessary membrane area. Greatest success was achieved using supported $Ba_{0.5}Sr_{0.5}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (BSCF) membranes [2]. However, BSCF suffers from low structural [3] and chemical stability e.g. in CO_2 containing atmospheres [4], which so far prevents industrial application requiring a lifetime of 40,000 to 100,000 operating hours. Therefore, $(La,Sr)(Co,Fe)O_{3-\delta}$ (LSCF) already discovered decades ago by Teraoka [5] attracts again increasing interest due to its higher stability and proven application as cathode in solid oxide fuel cells (SOFC) for ten thousands hours [6] in pilot scale. However, the permeability of e.g. $La_{0.58}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ is around one order of magnitude lower than BSCF

Therefore, in this work the concept of preparing thin supported membrane layers was used in order to investigate the permeation rate enhancement potential of LSCF materials. Furthermore, the specific permeability of LSCF is tailored by varying the La/Sr-ratio and compared to BSCF, Figure 1.

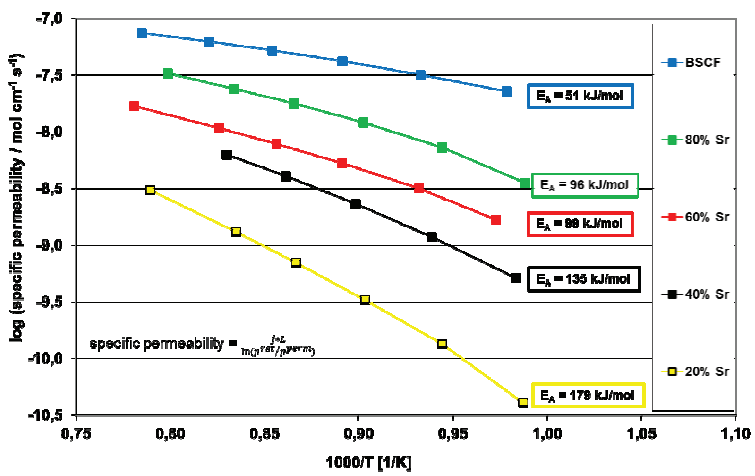

Figure 1 specific permeability of $La_{0.98-x}Sr_xCo_{0.2}Fe_{0.8}O_{3-\delta}$ in comparison to BSCF

As example, using $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ the permeation rate of a supported 20 µm thick membrane was enhanced by the factor of 4-5 compared to 1 mm thick disc membrane in an air/Ar gradient, figure 2. Permeation rates as high as 1 ml cm^{-2} min^{-1} at 800 – 850°C were achieved, which is close to the desired range for oxyfuel power plants [7]. From BSCF it is known that concentration polarization in the support is rate limiting for such membrane structures [2] so that further permeation rate enhancement can be expected when overcoming these limitation by e.g. using slight underpressure instead of a sweep gas at the permeate side (3-End concept). This leads to a breakthrough in the development of OTM for oxyfuel

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technology because it is the first time that sufficient high permeation rates are realized using a membrane material, which is stable towards diluted and concentrated CO_2.

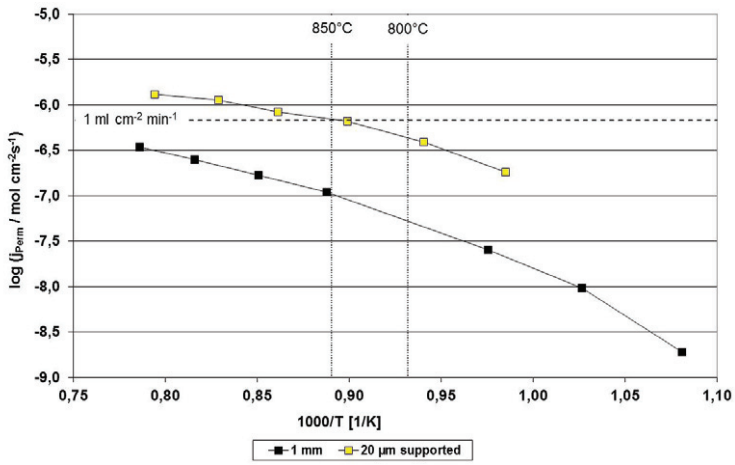

Figure 1 oxygen peremation rates for 1 mm and 20 µm membrane thickness, respectively, made of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$

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